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GUEST EDITORIAL

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Special issue on 6G and satellite communications

The fifth-generation (5G) technology has recently been consolidating its function as an infrastructure for new services, such as ultrareliable low-latency communications (URLLC) and massive machine-type communications, by further expanding the high-speed data service of the mobile communication system. Due to the successful deployment of the 5G technology, the sixth generation (6G) is expected to develop in the direction of further dramatically improving 5G services, such as the ultramobile broadband, ultra-low-latency reliability and security, and ultrahigh-sensing low-latency communications. The 6G technology will make a decisive contribution to the realization of new service concepts, such as metaverse services combined with new technologies like artificial intelligence and block chain. These new 6G services may be implemented by more intelligent infrastructure and ultra-wideband media that go beyond 5G. Beyond the conventional terrestrial communication coverage, 6G is expected to support non-terrestrial coverage using unmanned aerial vehicles and low Earth orbit (LEO) satellites to serve the three-dimensional spatial coverage, such as high-rise buildings, aerial places, and seas. This will further accelerate newly emerging services by unmanned vehicles that will cross the ground and air in the future.

In this sense, for this special issue, we have selected eight key papers in the three aspects of the 6G technology: (i) intelligent networks and protocols for enhancing reliability and user privacy; (ii) improved topology and transceiving for boosting performances; and (iii) extension to non-terrestrial networks.

The first two papers discussed intelligent networks and protocols for enhancing reliability and user privacy. Their proposed algorithms enabled networks to provide more reliable paths and stronger security, respectively.

In their paper titled [1] "Reliability-guaranteed Multipath Allocation Algorithm in Mobile Network," Lee and Ko investigated the method of selecting higher reliable network paths for further enhancing URLLC services. To achieve a more cost-efficient reliability, this study proposed a constrained Markov decision process (CMDP)-based algorithm for selecting paths over wireless and wired networks, which can consider both the path setup time and the dynamicity of path reliability. This work demonstrated that the proposed algorithm reduces the network cost by 30% through event-driven simulations. Furthermore, the CMDP-based algorithm well reveals design guidelines to adapt the numbers of allocated gNBs and CN paths to the required reliability.

The paper titled [2] "Dynamic ID Randomization for User Privacy in Mobile Network" by Sarker and others proposed ID-RZ, a new dynamic randomization scheme managing the temporary secure IDs for 5G and 6G networks. ID-RZ is designed to proactively change the IDs of mobile devices, providing better security at an arbitrary moment. This work demonstrates that ID-RZ is lightweight compared to conventional ID reallocation schemes retrieving a randomized ID from the network owing to its property of local generation of unpredictable temporary IDs using a hash-chain-based construction starting from the seed ID originally provided by the network.

The four papers below discussed the improved topology and transceiving for improving performances. They investigated mmWave cell-free massive MIMO, optical wireless networks, deep learning (DL)-based channel estimation, and beamforming for the mmWave URLLC, respectively.

The paper [3] "Energy-Efficient mmWave Cell-Free Massive MIMO Downlink Transmission with Low-Resolution DACs and Phase Shifters" proposes a novel framework for energy-efficient mmWave CFmMIMO systems using low-resolution digital–analog converters (DACs) and phase shifters (PSs) to introduce low-complexity hybrid precoding. The simulation results show that the proposed hybrid precoding and pilot allocation scheme outperform the existing schemes. Further, they show that low-resolution DACs and PSs can effectively increase the energy efficiency by compromising the spectral efficiency and network power consumption.

Nath and others provided the second paper [4] "Interference and Noise Analysis for Hybrid FSO/RF based 6G

Mobile Backhaul," which investigates hybrid free-space optics (FSO) and radio frequency (RF) systems as possible configurations for a mobile backhaul in the 6G network. Cognitive radio technology was used to combine RF with FSO to enhance the link availability, and the paper presented performance analysis in terms of outage probability and average bit error rate by considering the impact of optical channel turbulence, RF interference, and other losses. It was shown that the presented configuration could enhance the utilization of existing RF resources, reducing the waste of RF spectrum. Authors also suggested interference management techniques as a future study item.

The paper [5] "Deep Learning-based Scalable and Robust Channel Estimator for Wireless Cellular Networks" presents a two-stage scalable channel estimator (TSCE) that uses a DL-based scalable and robust channel estimator comprising two DL networks to efficiently support different resource allocation sizes and reference signal configurations. The results show that the proposed TSCE system can learn the wireless propagation channels correctly and outperform both traditional estimators and baseline DL-based estimators.

The paper titled [6] "Frequency divided group beamforming with sparse space–frequency code for above 6GHz URLLC systems" proposes a limited-feedback-based frequency divided group beamforming with sparse space–frequency transmit diversity coded orthogonal frequency division multiplexing (OFDM) system for URLLC systems. In this system, a novel power allocation method is proposed based on cooperative game theory to manage multipoint transmission structure realized by the distributed panels.

The last two papers investigated the resource allocation for non-terrestrial networks using unmanned aerial vehicles and LEO satellites.

The paper titled [7] "BandBlock: Bandwidth Allocation in Blockchain-Empowered UAV-based Heterogeneous Networks" by Kuna and others proposed a blockchain-enabled bandwidth allocation framework for secure bandwidth trading between terrestrial cellular base stations (CBSs) and UAV-assisted flying BSs (UBSs). Non-terrestrial UBSs can play a key role in complementarily serving UEs with unexpected dynamic traffic demands (TDs) or those experiencing poor coverage. The proposed blockchain-empowered bandwidth trading contributed to the enhancement of the transaction security and privacy without any centralized third party. The Cournot oligopoly game model was applied to the bandwidth allocation framework. This game model balanced the tradeoff between the bandwidth demands of the CBSs and the cost charged by the UBSs. The simulation results demonstrated that the proposed method enhances the network's transaction security and privacy protection for bandwidth trading and maximizes the UBS and CBS utilities.

The paper [8] "Dynamic Power and Bandwidth Allocation for DVB-based LEO Satellite Systems" proposes an efficient power and bandwidth allocation method employing two linear machine learning algorithms with inputs of channel conditions and TD. The simulation results conducted on multibeam frequency-reuse in LEO satellite systems show that the proposed method outperforms the existing methods.

The guest editors would like to thank all authors, reviewers, and editorial staff of ETRI Journal for making this special issue a success. We are most pleased to have been part of the effort of getting these high-quality technical papers timely. These leading studies for 6G will contribute to the design and realization of future 6G systems.

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We would like to thank all the authors for their contributions. We, unfortunately, had to reject some interesting contributions owing to space and time limitations associated with a special issue and its natural deadlines. We are highly grateful to the reviewers for their effort and to the ETRI Journal editorial board and the editorial staff.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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